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Object Detection for Autonomous Logistics: A YOLOv4 Tiny Approach with ROS Integration and LOCO Dataset Evaluation

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INTRODUCTION & AIM

Autonomous Mobile Robots (AMRs) are self-guided vehicles designed to move materials and goods from one point to another without human intervention. They use a combination of sensors, such as cameras, LiDAR, and ultrasonic sensors, along with sophisticated algorithms to perceive and interpret their surroundings in real-time. This enables them to navigate safely through cluttered spaces, avoid obstacles, and optimize their paths to accomplish tasks efficiently.

Despite their advanced capabilities, AMRs face several challenges in navigation and object detection within warehouse settings. These challenges include accurately identifying obstacles, localizing themselves within the environment, and navigating efficiently in dynamic and crowded spaces.

Therefore, it is essential to develop robust, accurate and real-time model to detect and localize object within the Logistics Objects .

METHOD

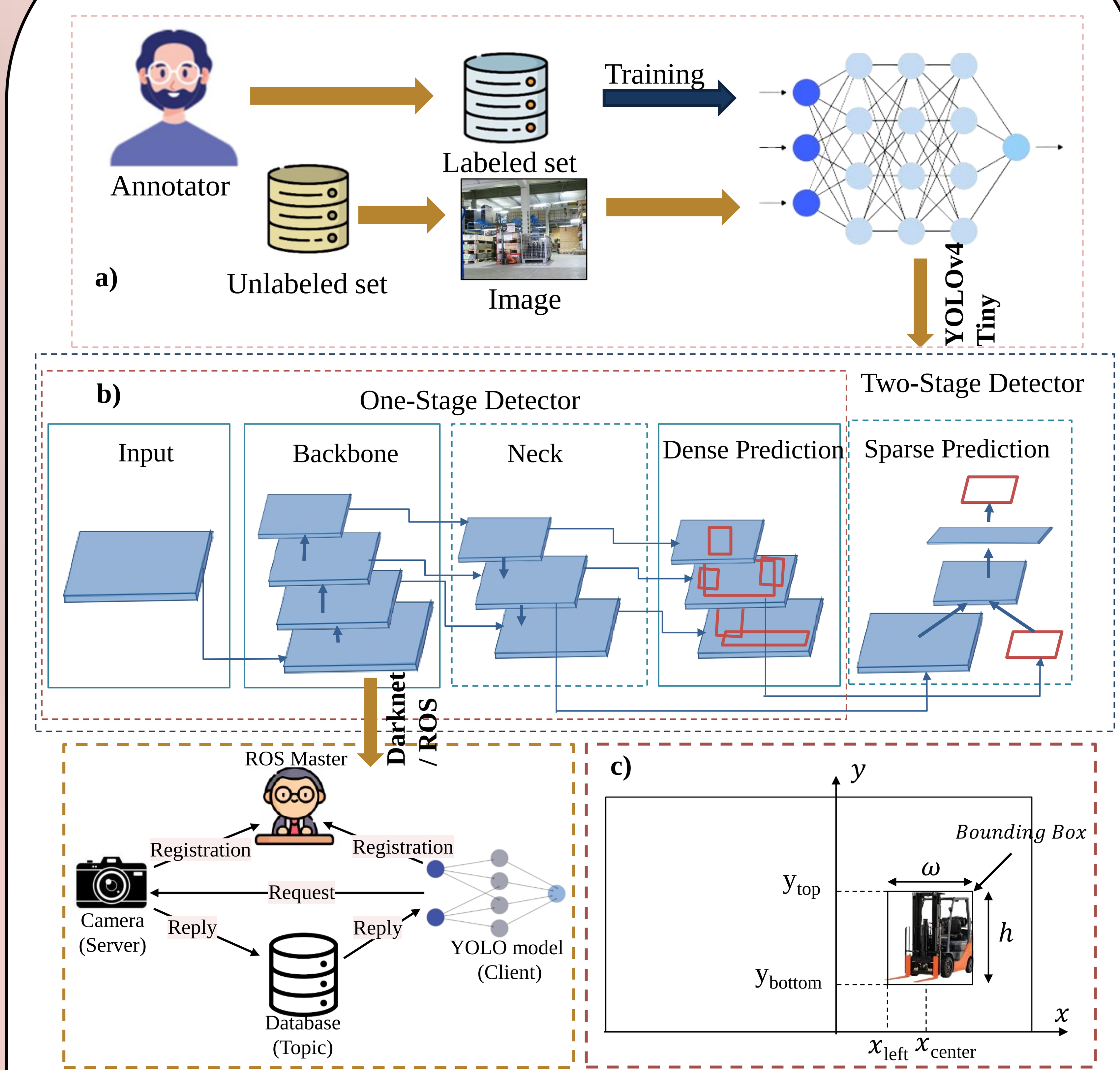


Figure 1. Proposed Model a) Data annotation and separation. b)YOLOv4 Tiny structure with ROS/ Darknet integration. c) Object detection using Bounding Boxes

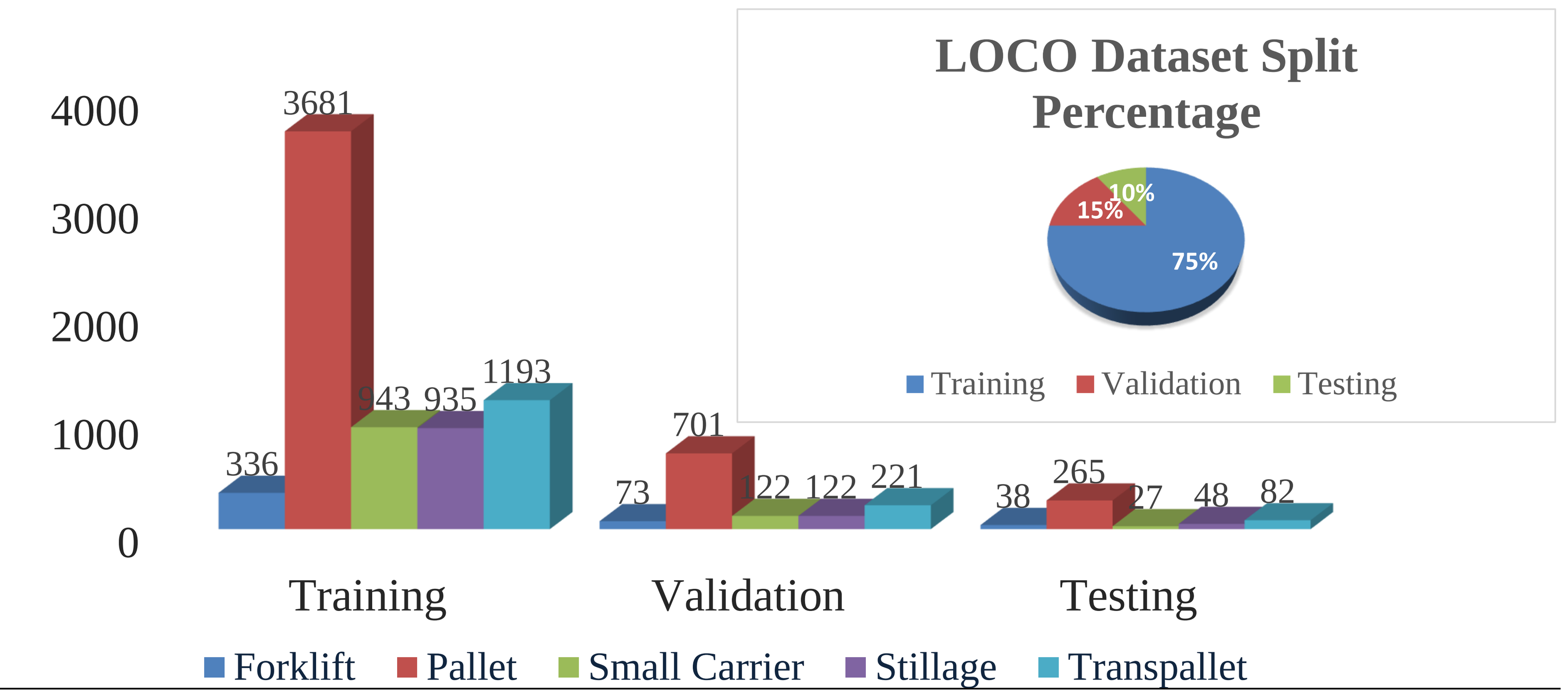
- We took advantage of the one-stage detection architecture You Only Look Once (YOLO) that prioritizes speed and accuracy. Focusing on a lightweight variant of this architecture: YOLOv4 Tiny
- The YOLOv4 Tiny model uses a CSPDarknet53 backbone, making it suitable for Robot Operating System (ROS) framework integration and deployment on edge devices.
- Bounding boxes are rectangular frames drawn around objects in images to precisely delineate their location: They provide essential spatial information.

CONCLUSION

- We presented LOCO, the first dataset focusing on scene understanding in logistics environments.
- This paper proposes an improved YOLOv4-tiny approach with ROS integration in terms of network structure. To reduce the consuming time of object detection

RESULTS & DISCUSSION

Figure 2. Different classes of the Logistics Objects in Context (LOCO) dataset



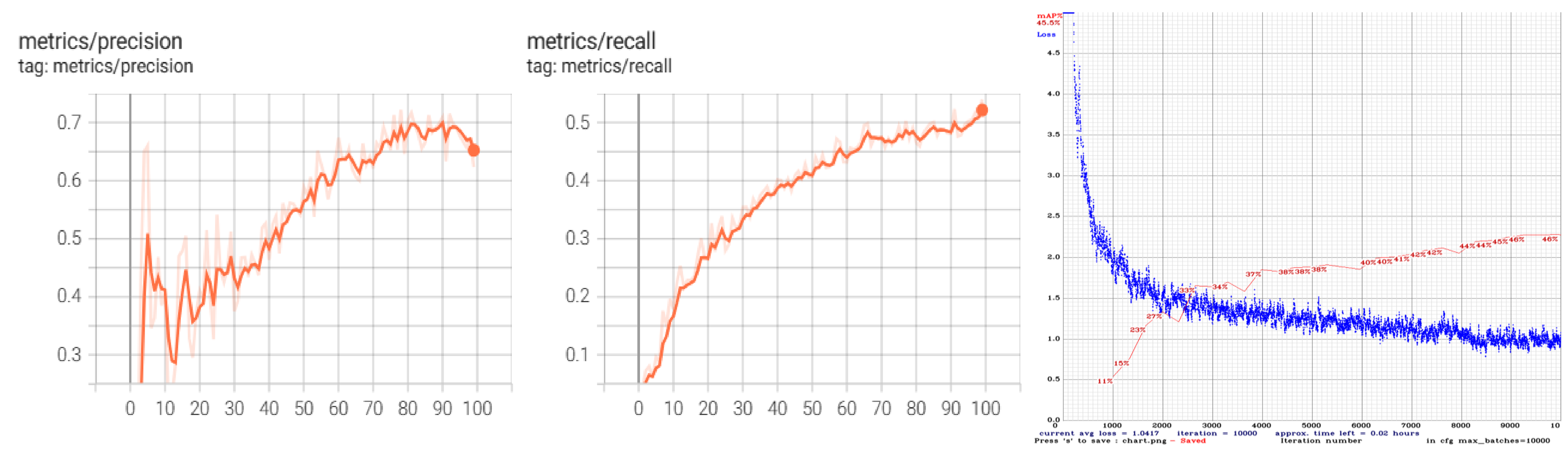


Figure 3. YOLOv4 Tiny object detection metrics : evaluation graphs

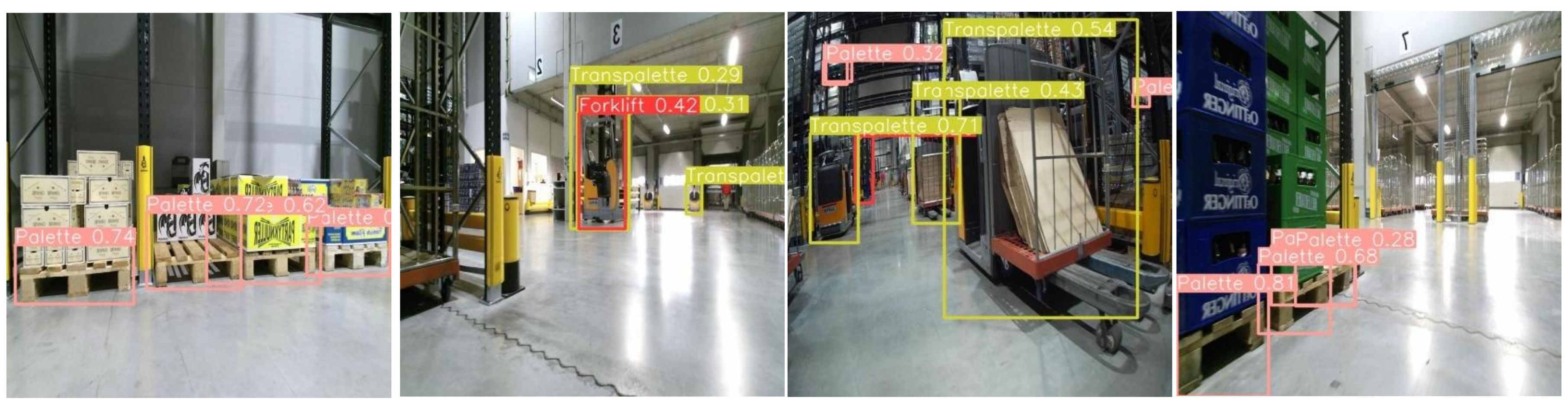


Figure 4. YOLOv4 Tiny object detection accuracy of LOCO dataset

Table I. LOCO class evaluation using YOLOv4 Tiny

Class Id	Name	Average Precision	True Positive	False Positive
0	Stillage	48,64%	516	275
1	Transpallet	54%	284	134
2	Forklift	53,25%	62	31
3	Pallet	38,28%	9652	5106
4	Small Carrier	53,25%	1319	841

Table II. Evaluation Results From the LOCO Dataset Publications

Name	YOLOv4	YOLOv4 Tiny	Faster R-CNN
mAP-50	41%	22,1%	20,2%
Stillage	27,7%	18,1%	28,3%
Transpallet	65,0%	36,2%	19,8%
Forklift	53,1%	31,3%	37,6%
Pallet	31,3%	11,6%	2,9%
Small Carrier	28,1%	13,3%	12,5%

$$\mathrm{IoU}(B_1,B_2)= \frac{\mathrm{Area}(B_1 \cup B_2)}{\mathrm{Area}(B_1 \cap B_2)}$$

$$mAP = \frac{\sum_{i=1}^{C} AP_i}{C} m$$

mAP@50=46% | IoU=50%

FUTURE WORK

- Convert the 2D bounding boxes of detected objects into 3D representations to determine their spatial positions accurately.
- Use the transformed 3D bounding boxes to visualize the detected objects within the ROS environment, to take in consideration the SLAM navigation.

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